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WATER RESOURCES STUDY WHITE RIVER BASIN (PINE RIDGE UNIT) SOUTH DAKOTA

Public Health Service
Kansas City, Missouri

May 1963

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WATER RESOURCES STUDY
WHITE RIVER BASIN
(Pine Ridge Unit)
South Dakota

Prepared for

BUREAU OF RECLAMATION

Missouri-Oahe Projects Office

Huron, South Dakota

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VI
Kansas City, Missouri

MAY 1963

TABLE OF CONTENTS

LIST OF TABLES and EXHIBITS iii

I. INTRODUCTION

Authority I-1

Purpose and Scope I-1

Acknowledgments I-1

II. SUMMARY AND CONCLUSIONS

Summary II-1

Conclusions II-1

III. DESCRIPTION OF PROJECT

Purpose III-1

Location III-1

Hydrology III-1

Water Quality III-1

Pertinent III-2

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries IV-1

General Features IV-1

V. ECONOMY

Present V-1

Future V-4

VI. HYDROLOGY

Surface Water VI-1

Ground Water VI-4

VII. MUNICIPAL AND INDUSTRIAL WATER SUPPLY NEEDS

Present VII-1

Prospective VII-2

Value of Storage VII-3

VIII. STREAMFLOW REGULATION FOR QUALITY CONTROL

Present Uses VIII-1

Prospective Uses VIII-1

Value of Storage VIII-2

IX. BIBLIOGRAPHY IX-1

X. APPENDIX X-1

XI. MAP OF AREA (Fold Out) XI-1

LIST OF TABLES

Table No.		Page
V-1	Population Trends	V-1
V-2	Number of the Labor Force by Major Classification	V-2
V-3	Agricultural Trends	V-2
V-4	Manufacturing Employment	V-3
V-5	Value of Mineral Extraction	V-3
V-6	Population Projection	V-4
VI-1	Quality Analysis of the White River	VI-2
VI-2	Sediment Rates and Allowances in Proposed Reservoirs.	VI-4

APPENDIX

Exhibit No.		
1	Flow Data - White River at Slim Butte Damsite	X-1
2	Frequency of Streamflows in the White River at Slim Butte Damsite	X-2
3	Duration of Low Flows at Slim Butte Damsite for Selected Recurrence Intervals	X-3
4	Frequency of Streamflows in the White River at Chadron, Nebraska	X-4
5	Duration of Low Flows at Chadron, Nebraska, for Selected Recurrence Intervals	X-5
6	Historical Streamflows in the White River Basin	X-6
7	Quality Analysis of the White River	X-7
8	Municipal Water Supplies	X-8
9	Chemical Analyses of Municipal Water Supplies	X-9
10	Municipal Waste Treatment Facilities	X-10

I. INTRODUCTION

Authority

The Bureau of Reclamation, Region 6, in a letter dated August 6, 1962, requested the Public Health Service, Region VI, Kansas City, Missouri, to make an investigation of the municipal and industrial water supply and water quality control needs in the White River Basin. This study is in accordance with the terms of the Federal Water Pollution Control Act and the Federal Water Supply Act, both as amended in 1961 by Public Law 87-88.

Purpose and Scope

This report is concerned with the need for and value of storage in the proposed Slim Butte Reservoir to satisfy the 50- and 100-year prospective needs for municipal and industrial water supply and water quality control in the White River Basin. Special consideration has been given to Dawes County, Nebraska, and Shannon County, South Dakota, since the largest demands for water from the proposed projects are expected to occur in these counties.

Acknowledgments

This report has been written in cooperation with the Bureau of Reclamation, Missouri-Oahe Projects Office, Huron, South Dakota. Assistance and cooperation by the following organizations is gratefully acknowledged:

1. South Dakota Department of Health
2. Nebraska State Department of Health
3. City of Chadron, Nebraska

II. SUMMARY AND CONCLUSIONS

Summary

1. The White River is a minor western tributary of the Missouri River. Approximately 8,500 square miles of the basin's area are in southwestern South Dakota and 1,700 square miles are in northwestern Nebraska.
2. The Bureau of Reclamation proposes to irrigate the Pine Ridge Unit, a section of the White River Division, Missouri River Basin Project.
3. The proposed Slim Butte Reservoir is intended to provide irrigation water, primarily for use within the unit.
4. For the purpose of this report, the entire White River Basin has been studied, but special consideration has been given to the Shannon County, South Dakota, and Dawes County, Nebraska, areas.

Conclusions

1. The future White River Basin population is estimated as 94,000 in 2010 and 160,000 in 2060, with an urban segment of 49,000 and 120,000, respectively.
2. The largest anticipated future municipal and industrial water supply requirements are expected to be in the Chadron, Nebraska, area with a total of 4 mgd in 2010 and 12 mgd in 2060.
3. Ground water is considered the most feasible alternative source for supplying municipal and industrial water supply for the city of Chadron. Water from the aquifer would require less treatment and the power costs and capital outlay would be less. The cost of supplying municipal and industrial water is estimated to be $3,560,000, based on the cost of developing the well field and appurtenances in 1975 with enlargements in the years 2000 and 2020.

4. No large municipal or industrial polluters are expected to develop in the study area. Consequently, reservoir storage for water quality control is not recommended at this time.

III. DESCRIPTION OF THE PROJECT

Purpose

The Bureau of Reclamation proposes the development of the Pine Ridge irrigation unit, a section of the White River Division, Missouri River Basin Project. The proposed Slim Butte Reservoir will be used to impound water primarily for irrigation. 1/

Location

The Slim Butte Damsite is located in South Dakota five miles north of the Nebraska-South Dakota state line and downstream on the White River from Chadron, Nebraska.

Hydrology

The White River is typical of most streams in the Plains region. Most of the runoff occurs in the spring months following early spring thaws, and high flows also result from general rains. Low flows are common in the summer and winter months. Data on streamflow have been recorded by the U. S. Geological Survey for varying periods at 16 stations on the White and South Fork White Rivers since 1904. 2,3/ Synthetic data for other locations in the basin are also available through correlation of streamflow data from these 16 stations. See Exhibit No. 1.1/

Water Quality

The White River derived its name as a result of the milky color of its water. This is caused by sediments from the South Dakota Badlands which it

partly drains. Data on the water quality of the basin are available from records of the U. S. Geological Survey, who have been sampling water at five stations since 1945. 4/

Pertinent Data

The Pine Ridge Unit is located entirely within Shannon County, South Dakota. The Slim Butte Reservoir, which will serve this Unit, will contain 44,000 acre-feet of conservation storage space to serve the 12,700 acres of irrigable land in the Unit, and 16,000 acre-feet of inactive storage for 100 years of sediment deposition.

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries

For the purpose of this report consideration was given to the entire White River Division, however the Pine Ridge Unit (Shannon County) and the area around Chadron, Nebraska, (Dawes County), are emphasized since these are the only two areas with a potential demand for water from the proposed project. See Map of basin at the back of the report.

General Features

The topography of the basin ranges from Nebraska sandhills, along the basin's southern rim, through an area of scattered buttes and tablelands, to the rough and dissected terrain in South Dakota, produced by the northward extension of the river's tributaries.

The climate of the White River Basin is characteristic of the northern Great Plains region. This semi-arid area has long, cold winters with little snow, moist spring weather, and hot dry summers with infrequent rains up to cloudburst intensity. The temperature varies from a maximum of 119 degrees to a minimum of 42 degrees below zero. Precipitation averages 17 inches annually with two-thirds of the annual precipitation occurring during the May to September growing season. The rain, however, is not distributed uniformly throughout this period. 1/

The sparse population of the basin is essentially rural. The major portions of the Pine Ridge and Rosebud Indian Reservations are located in the basin.

Chadron, Nebraska, is the principal municipality in the study area. It is the county seat for Dawes County and the home of Nebraska State Teachers College. The city is served by rail and highway transportation and has the only airport in the basin with scheduled flights.

V. THE ECONOMY

Present

In 1960, approximately 85 percent of the White River Basin population (55,820) was rural. Since 1930 the total population has decreased from 75,953 to 55,820. During this period the rural segment decreased from 71,347 to 47,036, while the urban segment increased from 4,606 to 8,784. During the same period, Chadron, Nebraska, the largest municipality in the study area, had increased from 4,606 to 5,079. Table No. V-1 below depicts population data for the area. [5,6/]

Table No. V-1

Population Trends for the White River Basin [5,6/]

	1910	1920	1930	1940	1950	1960
Urban	2,687	4,412	4,606	4,262	7,939	8,784
Rural	41,625	57,186	71,347	60,332	50,612	47,036
TOTAL	44,312	61,598	75,953	64,594	58,551	55,820

The primary economic activities in the basin are services and agriculture. In 1960, of the total labor force (19,094) the services employed 53 percent, while agricultural employment made up 40 percent. Five percent of the labor force was unemployed, while manufacturing made up the remaining two percent. Table No. V-2 shows employment trends for the basin. [7,8,9/]

Agricultural employment has had a sharp decrease from 11,309 in 1940 to 7,603 in 1960. The number of farms and acres of cropland harvested has also decreased since 1949. However, the value of all farm products sold, based on the 1954 value of the dollar, has increased from $56.6 million in

1949 to $74.7 million in 1959. Farm consolidation, improved farming methods, and the shift from crop to livestock production has been largely responsible for this increased value with a smaller farm employment. Table No. V-3 depicts agricultural trends. 10,11,12/

Table No. V-2

The Number of the Labor Force by Major Classification 7,8,9/

White River Basin

1940 - 1950 - 1960

	1940	1950	1960
Farm	11,309	10,533	7,603
Mining	8	30	13
Manufacturing	272	313	389
TOTAL BASIC	11,589	10,876	8,005
TOTAL SERVICES	10,277	9,258	10,107
UNEMPLOYED	1,555	806	982
TOTAL LABOR FORCE	23,421	20,940	19,094

Table No. V-3

Agricultural Trends for the White River Basin* 10,11,12/

	Number of Farms	Cropland Harvested (Acres)	Value of Crops Sold (Dollars)	Value of Livestock & Livestock Prod. Sold (Dollars)	Value of all Products Sold (Dollars)
1949	6,878	2,412,709	[illegible]321,500	39,282,200	56,603,700
1954	6,118	2,252,717	18,478,989	34,370,302	52,849,291
1959	5,379	1,758,519	15,378,538	59,336,822	74,715,360

*Adjusted to the 1954 value of the dollar.

Manufacturing in the basin is limited mainly to the production of food and kindred products and printing and publishing. These establishments principally supply the local markets. Manufacturing employment data are shown in Table No. V-4.

Table No. V-4

Manufacturing Employment 7,8,9/

White River Basin

1940 - 1950 - 1960

	1940	1950	1960
Manufacturing	272	313	389
Fabricating metals, machinery, vehicles, other durables	22	39	54
Food and Kindred Products	90	125	141
Printing & Publishing	88	64	113
Others	72	85	81

Mineral extraction is limited to the production of sand and gravel and stone. The annual value of these minerals has declined from $950 thousand to about $220 thousand during the 1957 - 1960 period. Dollar value received is shown in Table No. V-5.

Table No. V-5

Value of Mineral Extraction 13,14,15,16/

White River Basin

1957 - 1960

(Thousands of Dollars*)

	1957	1958	1959	1960
White River Study Area	950	410	290	220

*Adjusted to the 1954 value of the dollar.

Future

The population of the basin is expected to increase at the same rate as the respective States and reach 160,000 by 2060. (Senate Select Committee on National Water Resources, Committee Print No. 5 "Population Projections and Economic Assumptions." 17/) Of this total 120,000 should be urban and 40,000 rural. Table No. V-6 shows these population projections.

Table No. V-6

Population Projections
White River Basin
1960 - 2060

	1960	2010	2060
TOTAL	55,820	94,000	160,000
Urban	8,784	49,000	120,000
Rural	47,036	45,000	40,000

The study area offers no specific advantages over the surrounding areas. Industrial production will probably continue to be limited to supplying the local market.

Irrigation will increase agricultural production with some subsequent increase in the service and manufacturing related to agricultural products.

VI. HYDROLOGY

Surface Water

Streamflow

Records of streamflow have been maintained by the U. S. Geological Survey for varying periods at 16 stations on the White and South Fork White Rivers since 1904. Streamflow data from the Oacoma, South Dakota, Station, where the White River empties into Fort Randall Reservoir, together with data from three other stations in the basin, have been analyzed and correlated in order to estimate flows at other points on the river. From this synthetic data, the expected average annual flow at the Slim Butte Damsite is 29,200 acre-feet (see Exhibit No. 1 in the Appendix). 1/ Data from this exhibit have been used to show the flow characteristics of the river at this station. In Exhibit No. 2 is shown the low-flow frequency of the White River for various durations.* Exhibit No. 3 shows that the mean monthly flow is less or equal to 2 acre-feet 65 percent of the time, while 98 per cent of the time, the mean monthly flow is equal to or less than 10 acre-feet. Exhibits No. 4 and No. 5 point out similar conditions that prevail at Chadron, Nebraska, where the average annual flow is 20,000 acre-feet. 1/

Exhibit No. 6 shows that the 18-year average flow at Oglala is about 43,290 acre-feet (59.8 cfs (cubic feet per second)). The maximum flow at this station, located seven miles downstream from the dam, occurred June 21, 1947, and measured 5,200 cfs. Several periods of no flow occurred in 1952, 1954, 1957, and 1961. At Oacoma the 33-year average flow is 527 cfs (381,500 acre-feet per year). Maximum discharge recorded was 51,900 cfs on March 30.

*Using partial series method as suggested by Stall.18/

1952. Minimum flow measured 0.5 cfs on several occasions in 1936.

Water Quality

The U. S. Geological Survey has been sampling water at five stations in the basin since 1945, but not continuously at any one point. 4/ The water impurities at Oglala, in several cases, exceed the recommended levels of the U. S. Public Health Service Drinking Water Standards, but are considered satisfactory for irrigation. The table below shows the average concentrations of selected water quality parimeters at three stations on the main stem of the White River.

Table No. VI-1

Quality Analysis of the White River

Station (South Dakota)	Oglala	Kadoka	Oacoma
Average flow (cfs)	59.8	283	527
Test (average concentrations, ppm)			
Sulfate (SO_4)	191	125	225
Dissolved Solids	556	503	580
Total Hardness (as $CaCO_3$)	249	83	217
Selenium	.01	.12	-

As indicated in the table above, sulfates at Oglala average 191 ppm (parts per million). Exhibit No. 7 in the Appendix shows that the sulfate concentrations range from 47 to 590 ppm. 1/ Dissolved solids average 556 ppm and range from 286 to 1,080 ppm. 1/ Selenium content is negligible.

Available records 4/ on the quality of the water in the White River at Kadoka, about 90 miles downstream from the damsite, show considerable improvement from the water sampled at Oglala. The water at Kadoka consists

mostly of runoff from the Badlands area below Oglala. The increased flow provides dilution to such an extent that sulfate concentrations in the water are reduced from an average of 191 ppm at Oglala to 125 ppm at Kadoka. Dissolved solids at Kadoka are reduced to an average of 503 ppm and range from 238 to 1,600 ppm, while total hardness has been reduced from 249 to 83 ppm. Selenium concentrations at this station, however, average 0.12 ppm and reach as high as 0.25 ppm, a substantial increase from the concentration at Oglala. This water contains residual sodium carbonate, together with a high sodium absorption ratio in excess of values considered permissible for irrigation water. The combination of water and soils* in the area upstream from Kadoka near Weta, South Dakota, produces unfavorable drainage problems. If this area were irrigated, the deterioration of the physical condition of the soil would increase the likelihood of toxic concentrations of selenium in the crops irrigated with this water. For this reason a proposed reservoir near Weta, which was to provide water for irrigation, is no longer being considered.[1/] The irrigation problems likely at Weta are not expected to occur in the Pine Ridge Unit since both the water and soil are considered satisfactory for irrigation.

Sediment

The following discussion is found in the "Appendixes to Report on White River Division," Book No. 1, which was prepared by the Bureau of Reclamation. [1/]

*Montmorillonite - a clay with a high lattice expansion.

"Downstream from the Oglala Station, near the middle of the basin, there is a considerable amount of Badlands topography. The White River formation which is exposed in this area is easily erodible and contributes large amounts of sediment to the White River. Sediment sampling at the Kadoka Station, which is located near the lower end of the South Dakota Badlands area, has been conducted for about six years."

The table below shows the expected sediment rates and allowances at three proposed reservoir sites in the White River Basin. 1/

Table No. VI-2

Reservoir	Average Annual Runoff (Acre-feet)	Suspended Sediments (Tons)	Reservoir Sediment Allowance (100-years)
Slim Butte*	45,500	237,000	16,000 acre-feet
Little White	107,500	285,100	17,000 acre-feet
Weta	175,900	6,616,400	720,000 acre-feet

*Assuming same rate as at Oglala gaging station

Ground Water

Most of the communities in the basin derive their water supply from shallow wells. See Exhibit No. 8.19/ The quality of the well water in the South Dakota portion of the basin generally is hard (as high as 402 ppm at Belvidere). In several cases the allowable concentrations of iron and sulfate of the U. S. Public Health Service Drinking Water Standards are exceeded. 20/ See Exhibit No. 9. 21,22/

In Nebraska, an extensive aquifer is located about 25 miles south of Chadron. Tests conducted on several irrigation wells located on this aquifer

indicate that the water is of excellent quality. It is estimated that a well in this aquifer will yield about 1,000 gallons of water per minute. [22,23/] Efforts are presently being made by the City of Chadron to secure Federal assistance in determining the extent and capacity of the aquifer.

VII. MUNICIPAL AND INDUSTRIAL WATER SUPPLY NEEDS

Present

The municipalities in the basin now use 2.4 mgd (millions gallons per day) of an available plant capacity of 6 mgd. (See Exhibit No. 8.) [19] Chadron, Crawford, and Murdo rely on surface water sources while the other municipalities use wells. The table on "Chemical Analysis of Municipal Water Supplies," Exhibit No. 9, [21,22] shows that almost all of the municipalities in South Dakota with wells have a water quality problem. Total dissolved solids range from 293 ppm to 1,973 ppm and average 851 ppm. Total hardness ranges from 24 ppm to 402 ppm and average 227 ppm. Iron averages 0.64 ppm and reaches as high as 2.6 ppm. Sodium concentrations range from 13 ppm to 791 ppm and average 187 ppm. Chlorides constitute a problem only at Draper where concentrations reach a level of 422 ppm. Belvidere and Kadoka use water with sulfate concentrations of 322 ppm and 1,024 ppm, respectively.

Kadoka, South Dakota

This municipality indicated an interest in a proposed reservoir near Weta, because of high concentrations of total solids (1,845 ppm), sodium, (524 ppm), iron (0.70 ppm) and sulfates (1,024 ppm) in its well water. Subsequent studies, however, have indicated that the selenium concentration in waters impounded at that site would exceed 0.01 ppm. [1]

Pine Ridge, South Dakota

This municipality is located 12 miles from the proposed reservoir. It is also located beside Clay Creek, downstream from White Clay Dam and upstream from Oglala Reservoir. The municipality recently added four new wells

to its water supply system, and is not expected to require additional water during the period of this study.

Chadron, Nebraska

Chadron derives its water from Chadron Creek. The city had a water quantity problem and indicated an interest in the proposed Slim Butte Reservoir, but it has now improved its water supply system by means of a 120 million gallon reservoir system used primarily to meet peak demands during the summer. The reservoir is filled during the winter by excess flow from Chadron Creek.[23/] Approximately 0.8 mgd of an available plant capacity of 2.0 mgd are presently used.

Prospective

Analysis of the study area indicates that Chadron, Nebraska, will continue to be the principal municipality in the basin and that the immediate area around Chadron will have the largest potential water requirement. The other two municipalities mentioned previously are expected to satisfy their requirements from local sources.

Since no large industrial water users are expected in the study area, future water needs have been determined on a per capita basis, using the projected urban population as a base. This per capita factor reflects public and commercial as well as domestic users. At present, this rate is 150 gpcd (gallons per capita per day) and totals 1.3 mgd. By the year 2010 the expected rate is 175 gpcd and by 2060 will reach 200 gpcd. Using the expected rates, the total municipal and industrial water usage in the basin

will be 9 mgd by 2010 and 24 mgd by 2060. The Chadron area is expected to be more highly urbanized than the other municipalities and consequently will have a higher rate of usage than the surrounding basin. It is estimated that approximately 4 mgd and 12 mgd will be needed in the Chadron area for municipal and industrial water supplies in the years 2010 and 2060, respectively.

Value of Storage for Municipal and Industrial Water Supply

The value of storage in the proposed Slim Butte Reservoir for municipal and industrial water supply can be approximated by the value of tangible and intangible benefits attributable to the project. In practice the measure of these benefits is approximated by the cost of achieving the same results by the most likely alternative means that would be utilized in the absence of the project.

Consideration has been given in this report to alternate sources of surface and ground water. Because of topographic and soil limitations, the surface source would consist of a single purpose reservoir located at the project site. Ground water of excellent quality, which needs no treatment other than chorination for disinfection, could be derived from an aquifer located 30 miles south of Chadron. The surface supply on the other hand would necessitate treatment to reduce turbidity and hardness, and higher pumping costs would also result from higher head losses. In addition, the city of Chadron is planning to utilize the aquifer as a source of supply. For these reasons the ground source is considered to be the most feasible alternative. The cost to secure this water is estimated to be $3,560,000 or $ 0.09/1,000 gallons.

VIII. STREAMFLOW REGULATION FOR QUALITY CONTROL

Present Uses

Sewage pollution is not a major problem on the White River below the reservoir. (See Exhibit No. 10.) [24/] The only communities which are discharging sewage in the proximity of the Pine Ridge Unit are: Chadron and Crawford, Nebraska, and Pine Ridge, South Dakota.

The City of Pine Ridge provides secondary treatment. The effluent from the sewage treatment plant enters Clay Creek and travels 20 miles by way of Oglala Reservoir before it passes the damsite.

Chadron, Nebraska, is constructing a waste stabilization lagoon to replace their septic tank. The city presently contributes the major portion of sewage in the basin to the White River. Preliminary data on the proposed lagoon, however, indicates that it is to provide complete retention of wastes.

Prospective Uses

The extent of natural pollution in the White River has not been established. Mineral concentrations are expected to increase from irrigation return flows, but these are not expected to interfere with downstream users. Caution should be exercised, however, in the use of synthetic fertilizers, insecticides, and weedicides which may have detrimental effects on the quality of the streams receiving irrigation return flows.

The water from the proposed reservoir will be available for use by a fish hatchery, which may be located below the dam. Consideration has also been given to trout fishing in the reservoir. In their report dated

April 1951, the Fish and Wildlife Service indicated that there would be moderate gains to fishing by the construction of the reservoir and also an increase in waterfowl use.

Reduction of the volume of sediment carried into Fort Randall Reservoir by the White River is highly desirable. Further studies conducted on this problem and the selenium problem at Weta may yield solutions which will permit utilization of the water from the proposed project.

In view of the numerous water users located downstream from Chadron, who use the river water primarily for stock watering, every precaution should be taken to insure that the stabilization lagoon is maintained and operated in accordance with State regulations.

For the period of study no large municipal or industrial sources of pollution are anticipated in the basin for which water for quality control would be needed.

Value of Storage

Inasmuch as the prospective water resource users in the study area are not expected to require significant streamflow regulation for water quality control, no value can be placed on related storage at this time.

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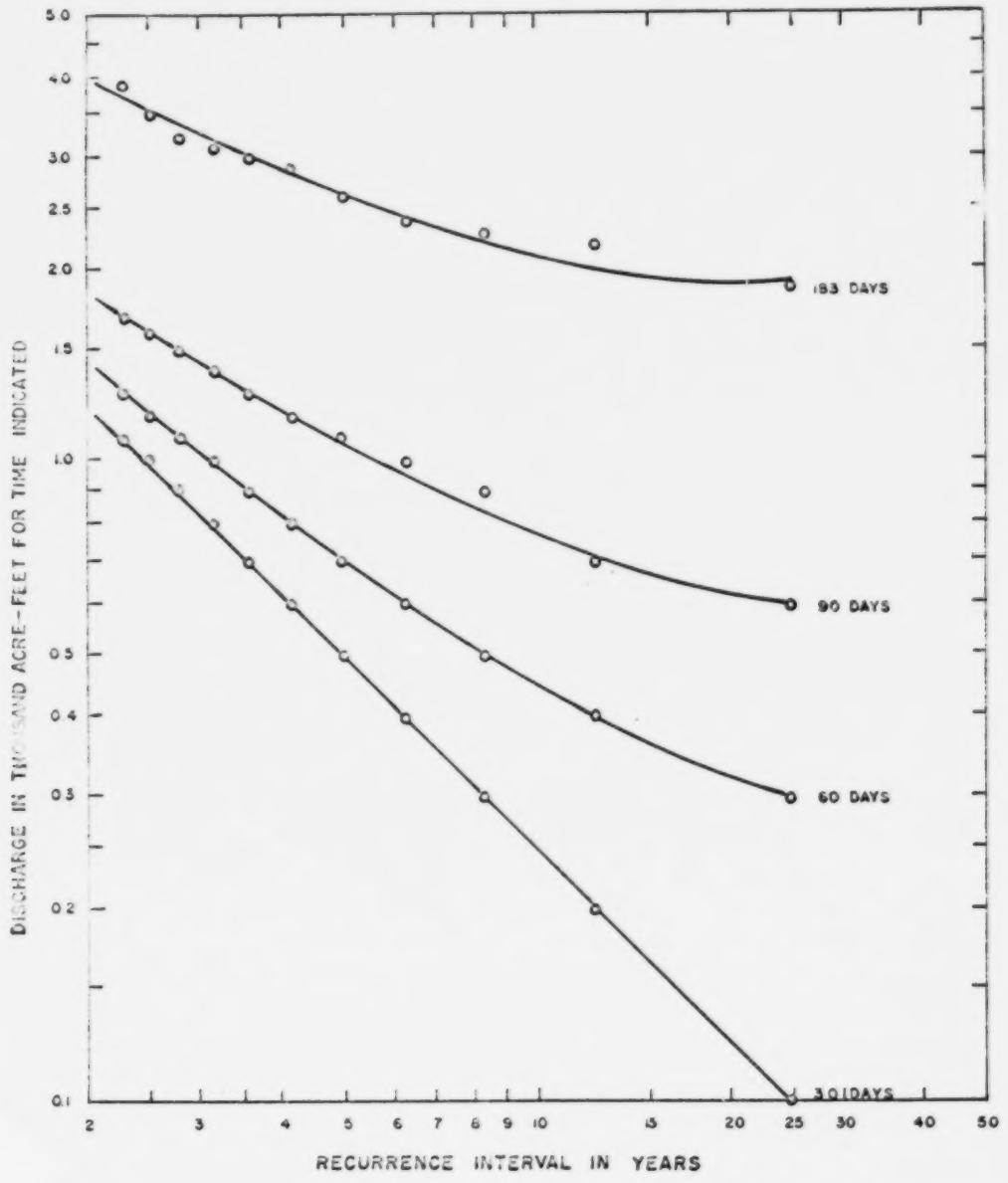
APPENDIX

EXHIBIT NO. 1 [1/]

Flow Data - White River at Slim Butte Damsite* (Units: 1000 Acre-feet)

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	TOTAL
1929	1.9	1.4	.8	.8	1.1	6.9	3.4	5.2	2.2	1.1	.9	2.3	28.0
1930	1.8	1.4	1.3	1.0	2.0	4.8	2.8	3.1	2.1	.7	.5	.5	22.0
1931	.9	1.5	1.3	1.4	1.7	3.1	.7	1.6	1.3	.2	.2	.5	14.4
1932	.6	1.1	1.8	1.8	2.4	2.5	6.1	3.5	.9	.5	1.0	.2	22.4
1933	.6	.6	.3	.8	.6	3.8	5.6	9.7	1.7	1.0	5.1	1.3	31.1
1934	1.0	1.7	2.3	2.2	1.7	2.0	1.4	.4	.4	.5	3.2	.3	17.1
1935	.5	.3	.8	.8	1.5	3.5	9.3	8.3	6.9	4.0	.3	.5	36.7
1936	.2	1.3	.5	.2	.7	1.8	2.1	.6	1.3	.2	.1	5.8	14.8
1937	.2	2.1	1.8	.8	1.3	1.6	1.5	2.1	3.9	.7	.5	.5	17.0
1938	.6	.4	.4	.6	.7	2.5	2.6	4.0	1.4	1.7	.6	.4	15.9
1939	.3	.8	.5	.3	.7	1.7	1.7	2.8	1.0	.5	3.2	.2	13.7
1940	.4	.4	.5	.4	1.2	4.8	4.8	1.4	1.1	.2	.5	2.0	17.7
1941	.2	.2	.2	.2	.2	1.2	3.3	.4	5.8	3.4	.3	.2	15.6
1942	.2	.4	.4	.4	.3	1.2	8.1	69.8	16.8	5.8	2.1	2.6	108.1
1943	1.9	1.2	1.2	1.1	1.6	4.2	4.0	4.2	7.6	4.2	1.0	.4	32.6
1944	.2	.6	.4	.3	.4	6.4	4.3	8.5	11.5	4.2	2.9	.9	40.6
1945	.6	1.3	.8	.5	.6	7.8	3.7	3.5	6.5	2.3	3.7	2.6	33.9
1946	1.1	1.1	.9	.9	1.4	4.8	1.2	8.5	7.1	1.1	1.1	3.2	32.4
1947	1.6	1.7	2.2	1.5	2.7	4.0	3.1	2.2	32.3	11.7	2.1	1.6	66.7
1948	1.6	1.1	1.6	1.1	1.4	5.4	2.8	4.0	4.7	2.6	2.2	.4	28.9
1949	.6	1.4	1.4	.6	3.6	30.5	4.5	6.9	4.3	2.6	1.0	1.0	58.4
1950	.7	.9	.7	.5	1.1	3.0	2.7	4.0	1.4	.8	.8	1.1	17.7
1951	.6	.7	.9	.9	1.1	1.7	1.4	1.5	5.4	5.3	1.5	3.3	24.3
1952	.9	.9	1.1	1.1	3.3	7.6	3.8	4.3	2.4	.8	.4	.4	27.0
1953	.4	.3	.3	.6	.6	6.8	1.8	4.0	2.0	1.1	2.6	.6	21.1
1954	.6	.4	.7	.5	1.1	1.6	1.1	4.5	1.9	.8	.8	.5	14.5
1955	.3	.5	.4	.4	.3	3.7	2.9	4.6	5.6	1.2	1.4	6.9	28.2
1956	.7	.4	1.6	.6	1.9	3.1	1.3	3.2	1.3	.8	.7	.4	16.0
TOTAL	21.2	26.1	27.1	22.3	37.2	132.0	92.0	176.8	140.8	60.0	40.7	40.6	816.8
Mean	.8	.9	1.0	.8	1.3	4.7	3.3	6.3	5.0	2.1	1.5	1.5	29.2
Percent	2.6	3.2	3.3	2.7	4.5	16.2	11.3	21.6	17.2	7.4	5.0	5.0	100.0

*Drainage area 1,475 square miles.
Streamflow modified for stockpond storage development.



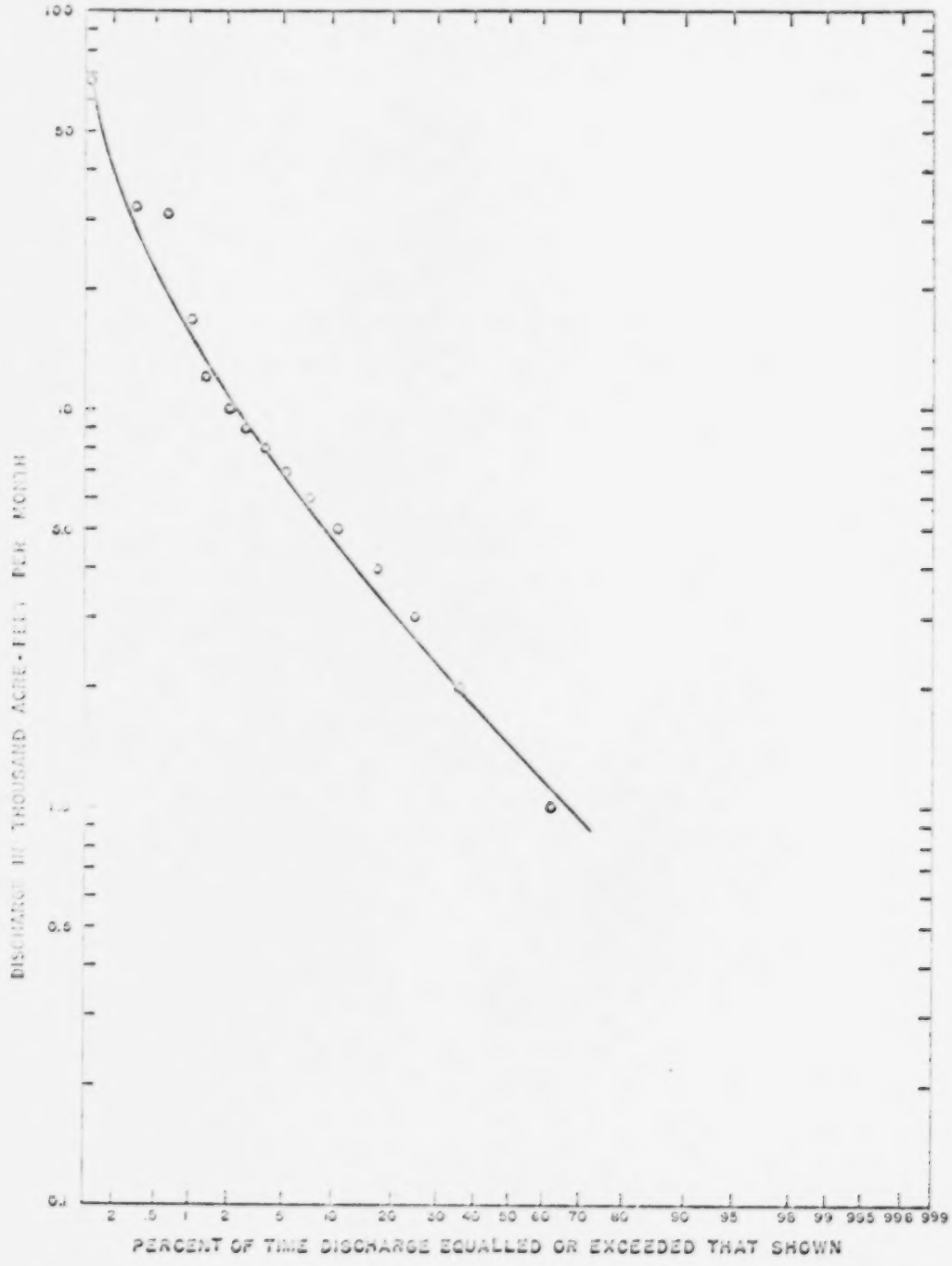
WHITE RIVER AT
SLIM BUTTE DAM SITE

LOW-FLOW FREQUENCY CURVES

APRIL 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

EXHIBIT NO. 2


100
50
10
5.0
1.0
0.5
0.1
DISCHARGE IN THOUSAND ACRE-FEET PER MONTH
2 .5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 995 998 999
PERCENT OF TIME DISCHARGE EQUALLED OR EXCEEDED THAT SHOWN

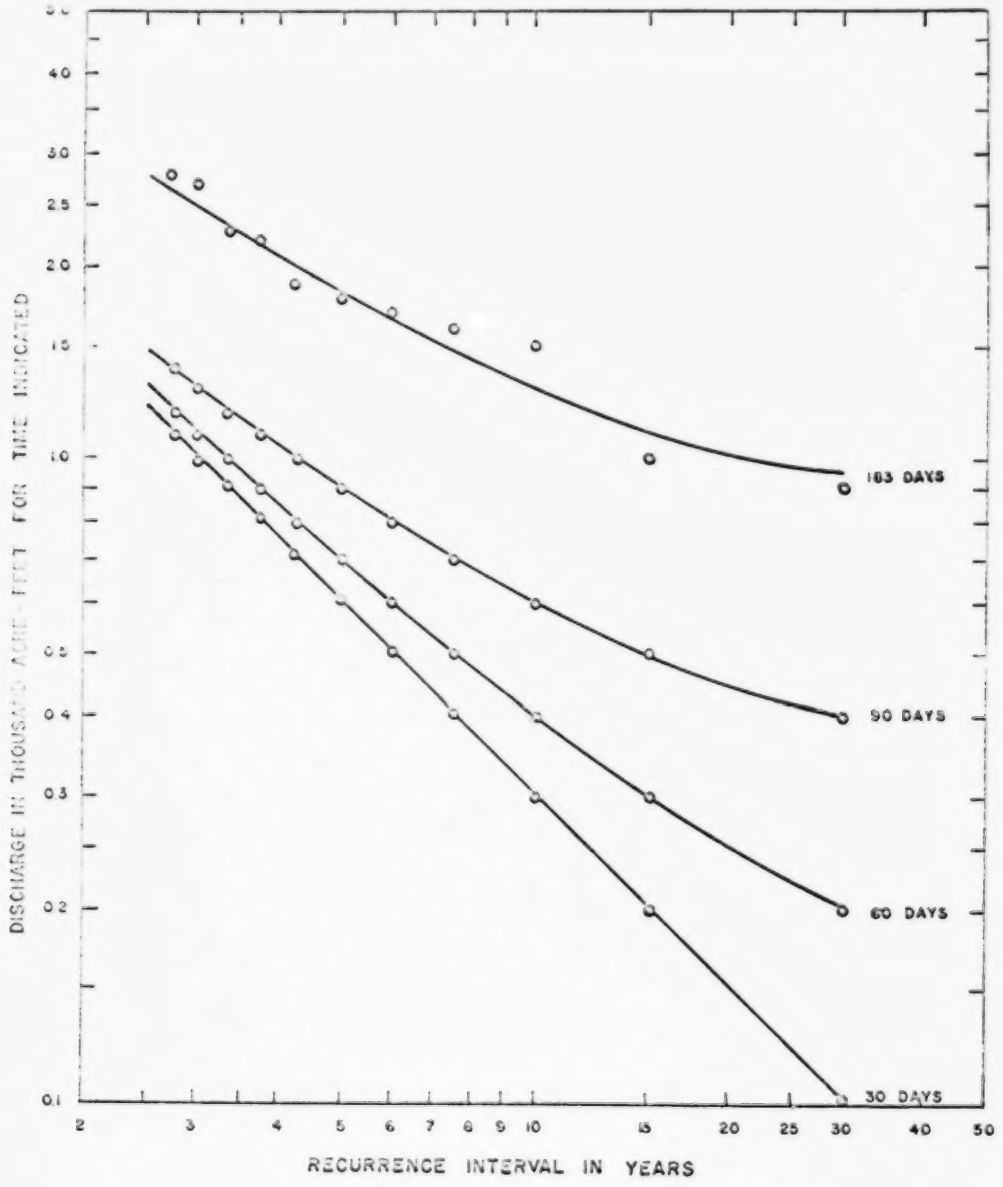
WHITE RIVER AT
SLIM BUTTE DAM SITE

DURATION CURVE OF MEAN MONTHLY RIVER FLOW

APRIL 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

EXHIBIT NO. 3



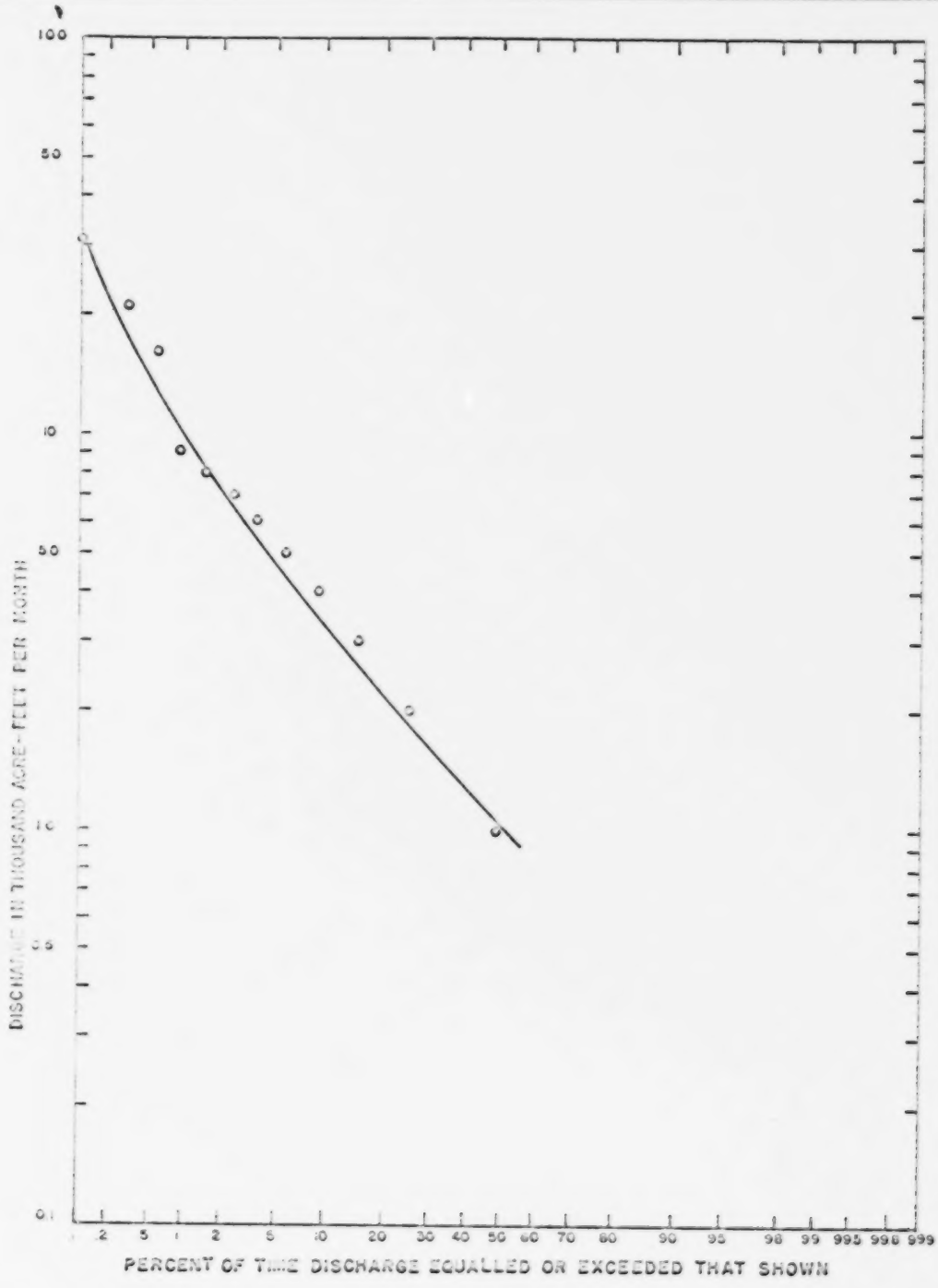
WHITE RIVER AT
CHADRON, NEBRASKA

LOW-FLOW FREQUENCY CURVES

APRIL 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

EXHIBIT NO. 4


100
50
10
5
1
.5
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DISCHARGE IN THOUSAND ACRE-FEET PER MONTH
.2 .5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9
PERCENT OF TIME DISCHARGE EQUALLED OR EXCEEDED THAT SHOWN

WHITE RIVER AT
CHADRON, NEBRASKA

DURATION CURVE OF MEAN MONTHLY RIVER FLOW

APRIL 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

EXHIBIT NO. 5

Exhibit No. 6

Historical Streamflows in the White River Basin [16,17]

Gage Location		River Mile	Years of Record	Flow (Cubic Feet/Second) Maximum	Minimum	Average
Near Whitney, Nebraska	½ mile downstream from Cottonwood Creek 4½ miles NE of Whitney	-	13	4,480	0	19.7
Near Oglala, South Dakota	3 miles downstream from Blacktail Creek and 7 miles NW of Oglala	-	18	5,200	0	59.8
Near Kadoka, South Dakota	5 miles upstream from Pass Creek 5 3/4 miles south of Kadoka	-	19	21,700	0	283.0
Near Oacoma, South Dakota	8 miles SW of Oacoma 16½ miles upstream from mouth	-	33	51,900	0.5	527.0

Exhibit No. 7

Quality Analyses of White River 1/

1945 - 1957

Station	OGLALA, SOUTH DAKOTA		KADOKA, SOUTH DAKOTA		OACOMA, SOUTH DAKOTA	
Average Flow (cfs)	59.8		283		527	
Test (ppm)	Range	Average	Range	Average	Range	Average
Iron (Fe)	0.00 - 0.50	.06	0.00 - 0.60	.08	0.00 - 0.20	.04
Sodium (Na)	28 - 139	82	59 - 466	130	40 - 209	110
Sulfate (SO_4)	47 - 590	191	20 - 639	125	73 - 555	225
Chloride (Cl)	0.9 - 20	10	0.4 - 30	8	2.2 - 70	14
Fluoride (F)	0.1 - 1.2	.53	0.0 - 1.2	.62	0.3 - 1.0	.65
Nitrate (NO_3)	0.2 - 6.0	2.4	0.0 - 6.2	2.1	0.0 - 7.0	1.9
Dissolved Solids	286 - 1,080	556	238 - 1,600	503	278 - 1,130	580
Total Hardness (as $CaCO_3$)	92 - 1,001	249	13 - 470	83	45 - 697	217
Percent Sodium	23 - 68	47	18 - 95	78	37 - 80	61
Sodium Absorption Ratio	1.1 - 3.8	2.5	3.1 - 28.0	8.8	2.1 - 5.4	3.6
Selenium	0.00 - 0.04	.01	0.01 - 0.25	0.12	- -	-

Exhibit No. 8

Municipal Water Supplies

White River Basin 18/

Municipality	1960 Population	Source	Plant Capacity or Maximum Draft (million gallons per day)	Average Plant Output (million gallons per day)
Chadron, Nebr	5,079	White River	2.000	0.800
Crawford, Nebr.	1,588	White River	1.200	0.600
Harrison, Nebr.	448	Wells	0.460	0.040
Whitney, Nebr.	98	Well	0.120	0.010
Belvidere, S. D.	232	Wells	0.120	0.015
Colome, S. D.	390	Wells	0.250	0.015
Draper, S. D.	215	Well	0.025	0.003
Interior, S. D.	179	Well	0.110	0.010
Kadoka, S. D.	840	Well	0.225	0.080
Martin, S. D.	1,184	Wells	0.550	0.090
Murdo, S. D.	783	Lake Murdo	0.288	0.050
White River, S. D.	583	Well	0.200	0.040
Winner, S. D.	3,705	Wells	0.500	0.500
			6.048	2,253

Exhibit No. 9

Chemical Analysis of Municipal Water Supplies

White River Basin [21,22/]

Municipality*		Source	Total Solids (ppm)	Total Hardness as $CaCO_3$	Iron (Fe)	Sodium (Na)	Chlorides (Cl)	Sulfates (SO_4)
Chadron, Nebr.	(T)	White River	318	198	0.0	21	6	23
Crawford	(T)	White River	260	178	0.0	16	7	10
Belvidere, S.D.	(T)	Wells	797	402	2.6	110	21	322
Colome	(C)	Wells	410	320	0.0	27	5	19
Draper	(R)	Well	1,973	24	0.7	791	433	3
Interior	(R)	Well	762	90	0.1	237	16	239
Kadoka	(T)	Well	1,845	207	0.7	524	73	1,024
Martin	(R)	Wells	298	164	0.05	15	6	22
Murdo	(T)	Lake Murdo	583	240	0.1	74	8	310
Pine Ridge	(R)	Wells	753	390	0.1	68	5	230
White River	(R)	Wells	697	399	2.1	69	13	239
Winner	(C)	Wells	293	196	0.0	13	3	18

*Indicates origin of sample.
(T) Treated Water
(R) Raw Water
(C) Composite Water Sample.

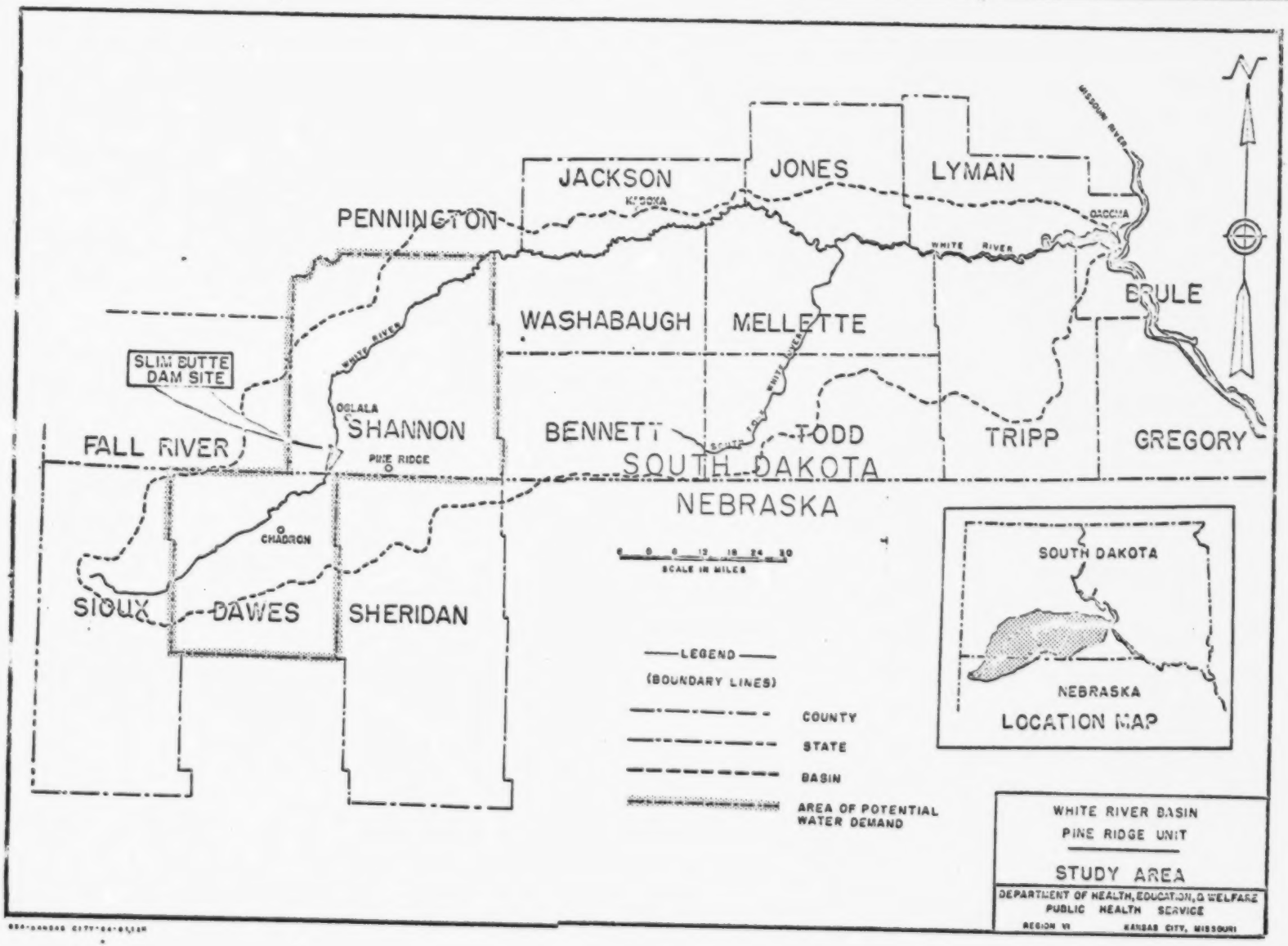
Exhibit No. 10

Municipal Waste Treatment Facilities [24/]

White River Basin

Municipality	Population Served	Type Treatment	Discharge To	Population Equivalent Biochemical Oxygen Demand	
				Raw	Treated
South Dakota					
Colome	380	Secondary	Ponca Creek	380	0
Kadoka	1,000	Secondary	-	1,000	0
Martin	1,150	Primary	Bear in the Lodge Creek, White River	1,150	450
Murdo	780	Secondary	Dry Draw to White River	780	0
Pine Ridge	1,000	Secondary	Clay Creek	1,000E	100E
Rosebud	350	Secondary	Rosebud Creek to White River	350E	50E
White River	580	Secondary	Little White River	580E	0
Winner	3,500	Secondary	Dog Ear Creek to White River	3,500E	700E
Nebraska					
Chadron	4,900	(Septic Tank)*	Chadron Creek to White River	4,900	4,900
Crawford	1,570	Secondary	White River	1,570	480E

*Present facilities to be replaced by wasce stabilization lagoon.


JACKSON
JONES
LYMAN
PENNINGTON
KADOKA
OACOMA
MISSOURI RIVER
WHITE RIVER
BRULE
WASHABAUGH
MELLETTE
WHITE RIVER
SLIM BUTTE DAM SITE
OGLALA
SHANNON
PINE RIDGE
BENNETT
TODD
TRIPP
GREGORY
FALL RIVER
SOUTH DAKOTA
NEBRASKA
CHADRON
SIOUX
DAWES
SHERIDAN
SCALE IN MILES
LEGEND
(BOUNDARY LINES)
COUNTY
STATE
BASIN
AREA OF POTENTIAL WATER DEMAND
SOUTH DAKOTA
NEBRASKA
LOCATION MAP
WHITE RIVER BASIN
PINE RIDGE UNIT
STUDY AREA
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII
KANSAS CITY, MISSOURI